SINGLE-NUCLEON TRANSFER REACTIONS

$^{24}Mg(\vec{p},d)$ ANALYZING-POWER MEASUREMENTS AT 95 MeV

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It is of interest to determine whether the characteristic ℓ- and j-dependence of the $(\vec{p},d)$ pickup reaction observed below about 60 MeV bombarding energy persists at higher bombarding energies where, in particular, the reaction could be useful for identifying "deep-hole" states inaccessible at lower energies. This summary presents final results of analyzing-power angular distribution measurements[1] for the $^{24}Mg(\vec{p},d)^{23}Mg^*$ reaction at E_p=95 MeV; DWBA analyses of some of the results have been presented elsewhere[2]. Cross-section measurements for the states in ^{23}Mg up to 13.28 MeV excitation, carried out at the same bombarding energy, have been reported previously.[3]

94.8 MeV polarized protons were used to bombard a 3.62 mg/cm^2 ^{24}Mg target, and reaction deuterons were momentum analyzed by the QDDM magnetic spectrograph in a one-arm analyzing-power measurement. The overall resolution was about 70 keV. Beam polarizations were monitored by a ^4He polarimeter, periodically inserted directly after the injector cyclotron (E_p = 8.3 MeV). No depolarization could be detected after acceleration in the main cyclotron. Typical beam polarizations were about +71% and -68% in the two spin orientations, with beam intensities on target of 40-100 nA.

Figure 1 shows the analyzing-power angular distributions obtained for known ℓ=0 and ℓ=2 pickup reactions to several low-lying states in ^{23}Mg. The two known ℓ=0 transfers in the left panel of Fig. 1 show essentially identical angular distributions, the large oscillation reaching nearly 90% at about 20°. Transfers with ℓ=0 are especially important for DWBA studies, since the analyzing power would be zero in the absence of spin-dependent distortions. The ℓ=2 transitions shown in the right panel of Fig. 1 exhibit a substantial j-dependence at angles arond 35°; unfortunately, little difference is seen at forward angles where the cross sections are large.

A very characteristic spin signature for ℓ=1 transitions at forward angles is shown for known states in the left panel of Fig. 2. The pronounced negative analyzing power observed for $p_{1/2}$ pickup at very forward angles has also been observed in this energy range with ^{13}C targets at 123 MeV at IUCF and at 200 MeV at TRIUMF.[4] The distributions presented in the right panel of Fig. 2 show the analyzing powers obtained in the present experiment for four deep-hole states previously assigned as ℓ=1 pickup in 95 MeV (p,d) cross-section studies.[3] A comparison of these angular distributions with the $p_{1/2}$ - $p_{3/2}$ spin signatures observed for the known states results in a $p_{1/2}^{-1}$ assignment for the 9.02 MeV and $p_{3/2}^{-1}$ assignments for the 8.91, 9.67, and 10.57 MeV deep-hole states. The latter spin assignments suggest a concentration of $p_{3/2}^{-1}$ strength at an excitation energy which is consistent with the predictions of a shell-model calculation[5] for the nearby nucleus ^{27}Si; little $p_{1/2}^{-1}$ strength is predicted by this calculation to lie this high in excitation.

These same four deep-hole states have been studied at IUCF using the $^{24}Mg(d,t)$ reaction at E_p = 76 MeV.[6] It is interesting to note that in the observed spectrum for the mirror reaction $^{24}Mg(d,^3He)$, also studied at 76 MeV, the only one of these four ^{23}Mg states for which

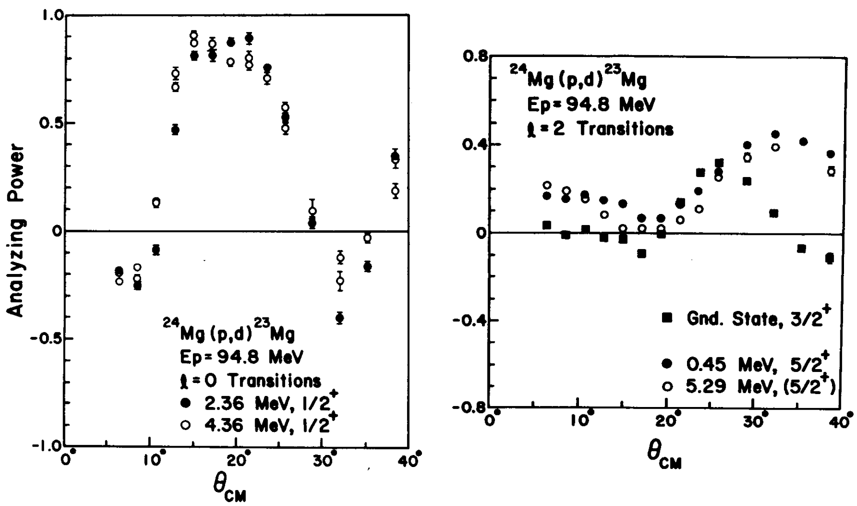

Figure 1. Analyzing power angular distributions for ℓ=0 and ℓ=2 transitions.

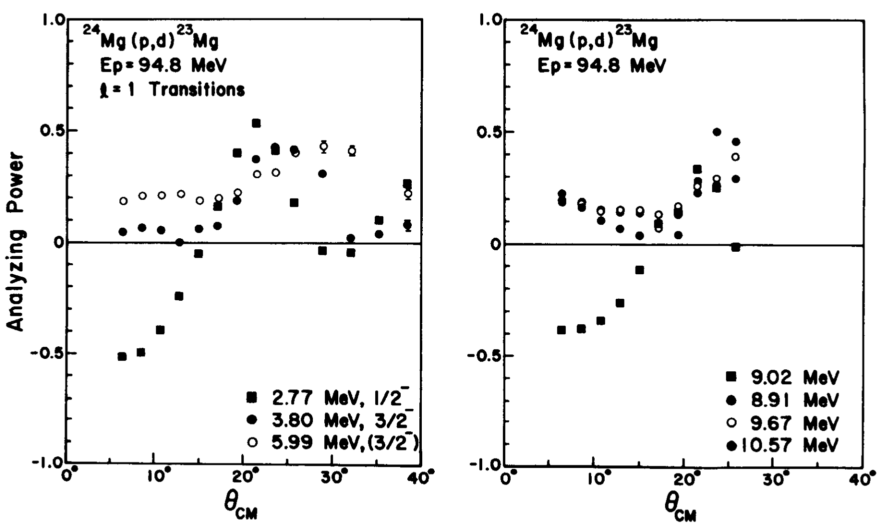

Figure 2. Analyzing power angular distributions for known ℓ=1 transitions.

there is no obvious mirror counterpart in the $p_{1/2}^{-1}$ state. Systematic (d,^{3}He) analyzing-power measurements at low energies for other sd-shell targets[7]) also fail to reveal any $p_{1/2}^{-1}$ strength except in the lowest-lying p state.

Analyzing powers for low-lying states believed to be excited in two-step processes[3]) in the ^{24}Mg(p,d) reaction were observed to vary slowly with angle and did not exceed 30%.

1) See also D.W. Miller, W.W. Jacobs, D.W. Devins, and W.P. Jones, 5th International Symposium on Polarization Phenomena in Nuclear Physics, Santa Fe, 1980.

2) J.R. Shepard, E. Rost, P.D. Kunz, 5th Int. Symp. on Polarization Phenomena in Nuclear Physics, Santa Fe, 1980; also University of Colorado Progress Report, 1980 (unpublished), p. 213.

3) D.W. Miller, D.W.Devins, R.E. Marrs and J. Kehayias, Phys. Rev. C20, 2008 (1979).

4) J.J. Kraushaar, J.R. Shepard, R.P. Liljestrand, J.M. Cameron, D.A. Hutcheon, W. J. MacDonald, R. McDonald, C. A. Miller, W. C. Olsen, J.G. Rogers, J. T. Tinsley and C. E. Stronach, University of Colorado Progress Report, 1980 (unpublished), p. 127.

5) S. Maripuu (private communication).

6) W.W. Jacobs, S.E. Vigdor, W.P. Jones, R.E. Marrs and D.W. Miller, IUCF Technical and Scientific Report, Feb. 1977 to Jan. 1978 (unpublished), p. 48.

7) H. Breuer et al., Annual Report, Max Planck Institut für Kernphysik, Heidelberg, 1977, p. 98.

ANALYZING POWERS FOR THE ^{13}C AND ^{208}Pb($\vec{p}$,d) REACTIONS AT 123 MeV

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We have measured differential cross sections and analyzing powers for the first two levels in the ^{13}C ($\vec{p}$,d) reaction and the first six levels in the ^{208}Pb($\vec{p}$,d) reaction at 123 MeV bombarding energy. The experimental method was the same as that described in the preceding report.[1] Several preliminary analyzing-power distributions for the ^{208}Pb($\vec{p}$,d) reaction appear in Figures 1 through 4.

The ^{13}C($\vec{p}$,d)^{12}C analyzing powers for the transitions to the 0^+ ground state ($p_{1/2}$ pickup) and the 4.44-MeV 2^+ level ($p_{3/2}$ pickup) are quite similar to those observed at 65 MeV[2] and 200 MeV.[3] The DWBA description of them is quite poor. The failure is comparable to that reported[4] for the ^{24}Mg($\vec{p}$,d)^{23}Mg (2.36-MeV $1/2^+$ level) at 95 MeV.[1]

In contrast to the ^{13}C($\vec{p}$,d)^{12}C data, the ^{208}Pb($\vec{p}$,d) analyzing powers show only slight $j>$ vs. $j<$ dependence based on comparisons of $p_{1/2}$ vs. $p_{3/2}$ and $f_{5/2}$ vs. $f_{7/2}$ angular distributions. All analyzing-power angular distributions show significant structure which becomes more pronounced for decreasing angular-momentum transfer.

Zero-range DWBA calculations were performed as described in Ref. 5 using optical potentials P7P and D3P of that reference. Some of these calculations appear as the solid curves of Figs. 1-4. Generally there is reasonably good agreement with the analyzing-power data in contrast with the very poor agreement observed for the lighter targets. Only for the 3.409-MeV $9/2^-$ level data shown in Fig. 4 is the agreement qualitatively poor.

Further analysis of these data is in progress.

1) D. W. Miller et al., 5th International Symposium on Polarization Phenomena in Nuclear Physics, Santa Fe, 1980, and contribution to this Ann. Rept.

2) K. Hosono et al., RCNP (Osaka) Annual Report, 1978, p. 7.

3) R. P. Liljestrand et al. (to be published); J. Kraushaar et al., University of Colorado Progress Report, 1980 (unpublished), p. 127.

4) J. R. Shepard, E. Rost and P. D. Kunz, 5th International Symposium on Polarization Phenomena in Nuclear Physics, Santa Fe, 1980.

5) R. E. Anderson et al., Nucl. Phys. A311, 93 (1978).